AE52: Beam Manipulation by Self-Wakefield at the ATF

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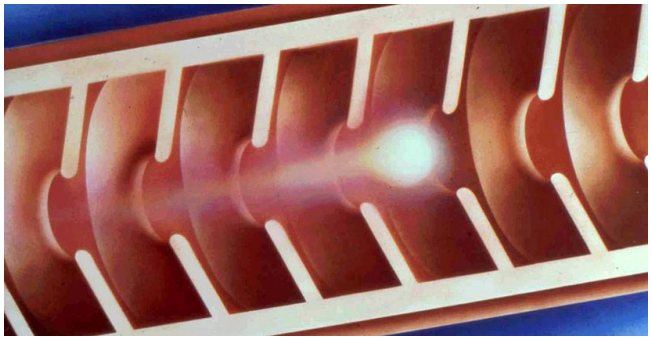
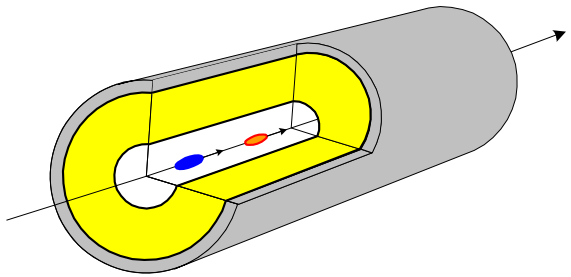
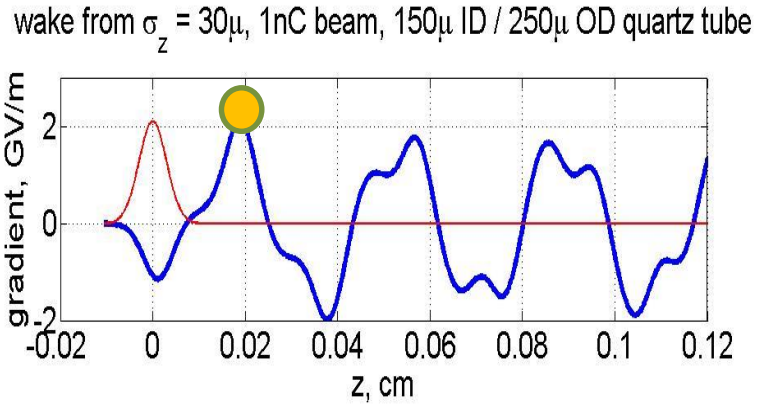
• AE52 - Beam manipulation by self-wakefield

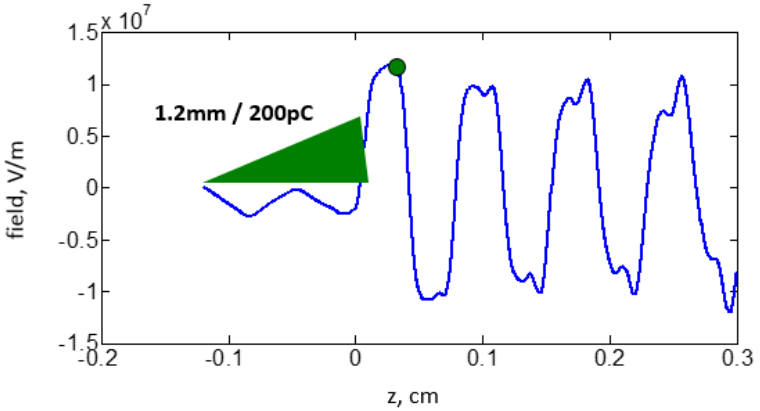
- Various structures
  - dielectric loaded, corrugated, single mode, multimode
- Study of wakefield (/THz)
- Study of self-wakefield
  - Dechirper, energy modulation, transformer ratio





Collinear Acceleration, Transformer Ratio

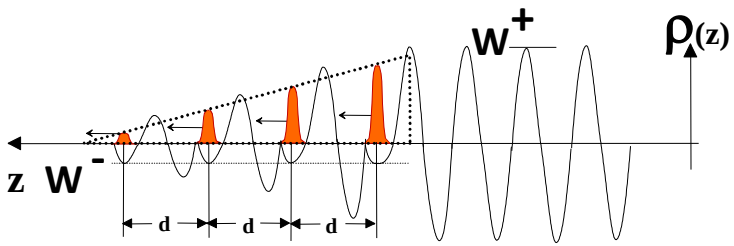




TR = 3.5 experiment at ATF, BNL

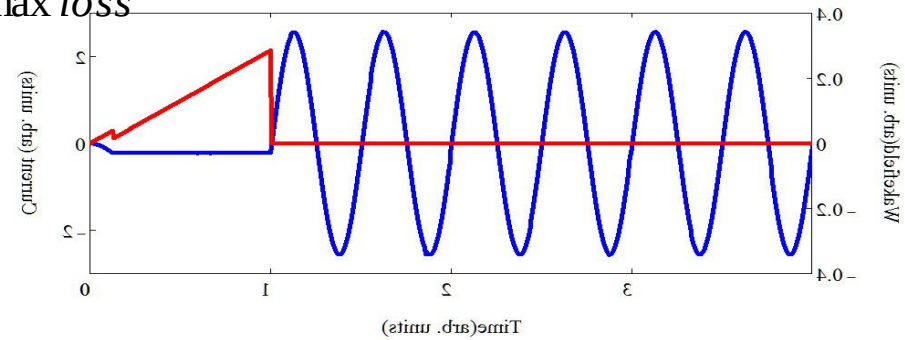
S. Antipov et. al., AAC 2014

Transformer Ratio: $$TR = \frac{E_{\max gain}}{E_{\max loss}}$$



TR = 3.4 experiment at AWA, ANL

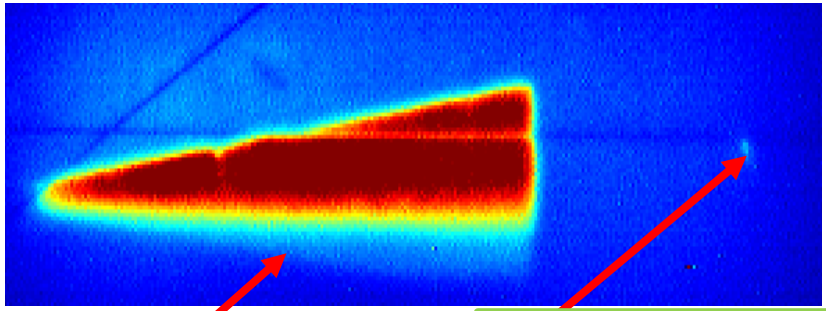
C. Jing et. al. PRL, 98, 144801, April (2007)



Collaboration with LANL (E. Simakov, D. Schegolkov) attempted at ATF... Small effect to measure

Transformer ratio measurement at ATF

Beam profile after the mask in a dogleg

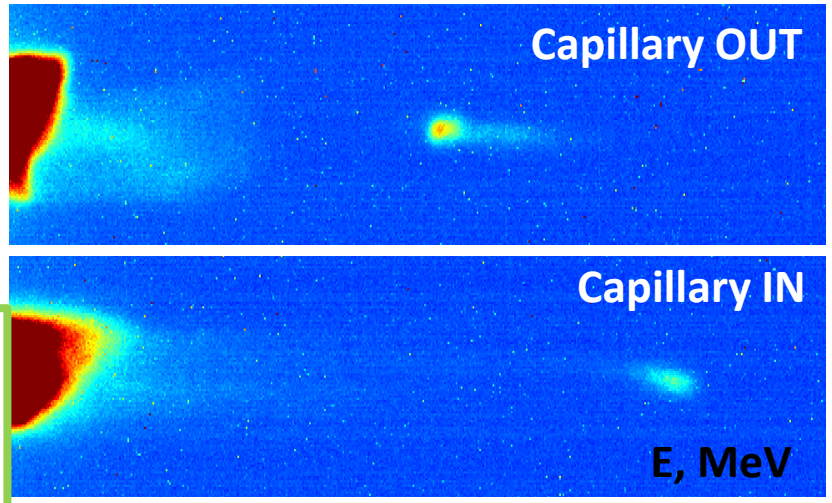


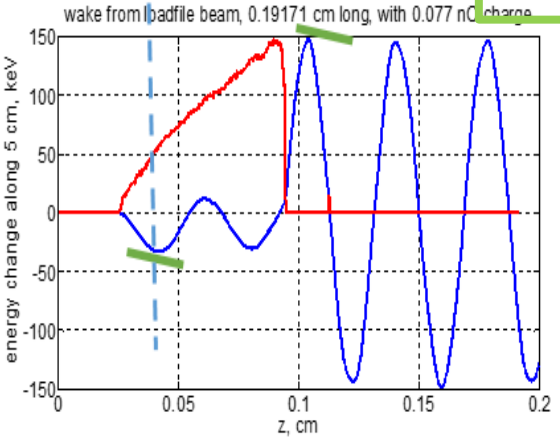
Drive (77 pC) and witness (3.5 pC)

Theoretical: 4.5

Measured: 3.5

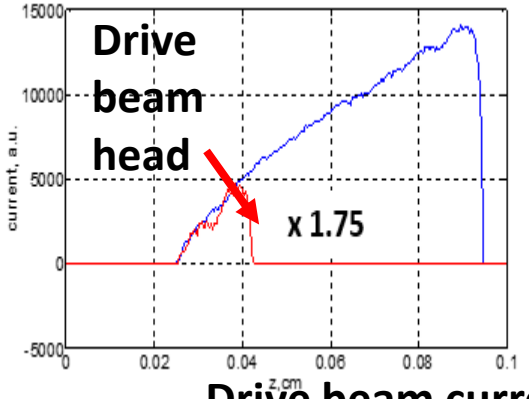
- Small witness beam: spectrometer





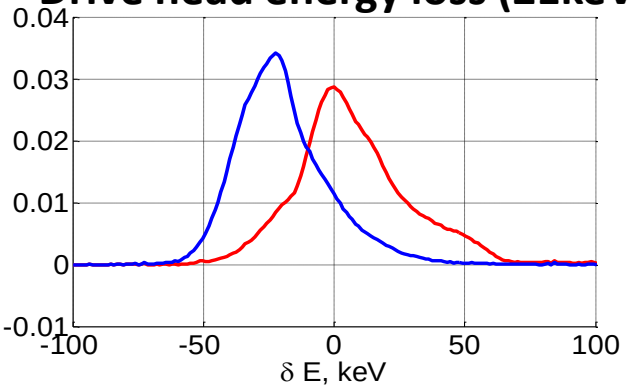
S. Antipov, AAC 2014

***preliminary data**



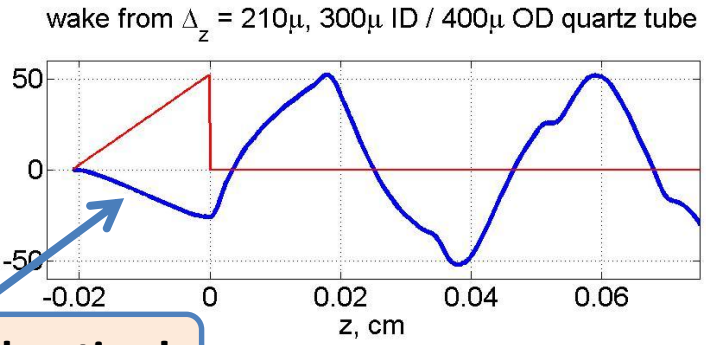
Drive beam current

Drive head energy loss (21keV)



Energy Chirp Correction Experiment at ATF

Triangular-shaped (current) beam with energy chirp

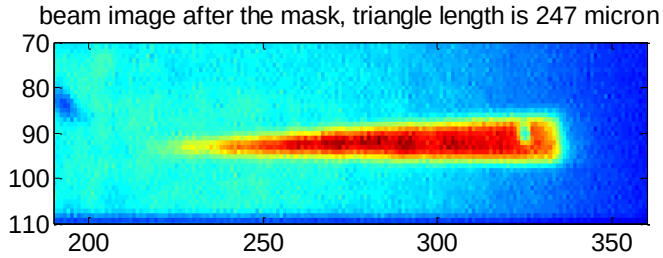


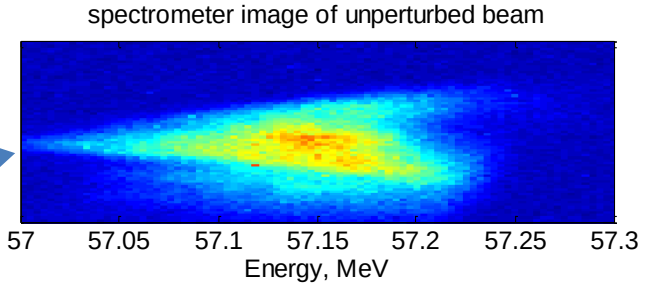
Self-deceleration!

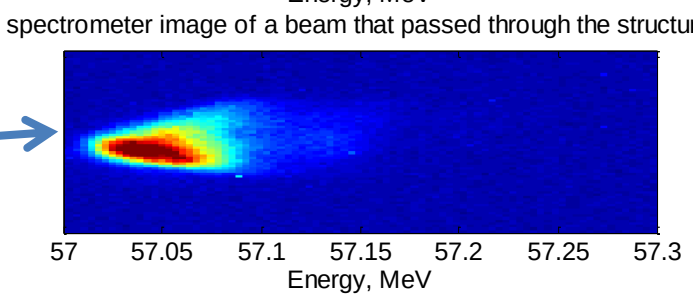
Chirp corrector – passive wakefield tube: dielectric loaded waveguide

Spectrometer image of the original beam

Spectrometer image after chirp corrector

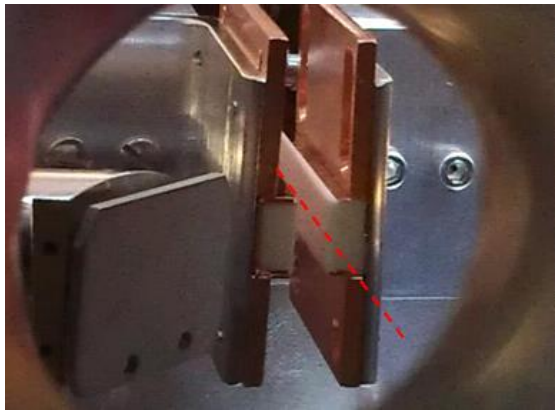




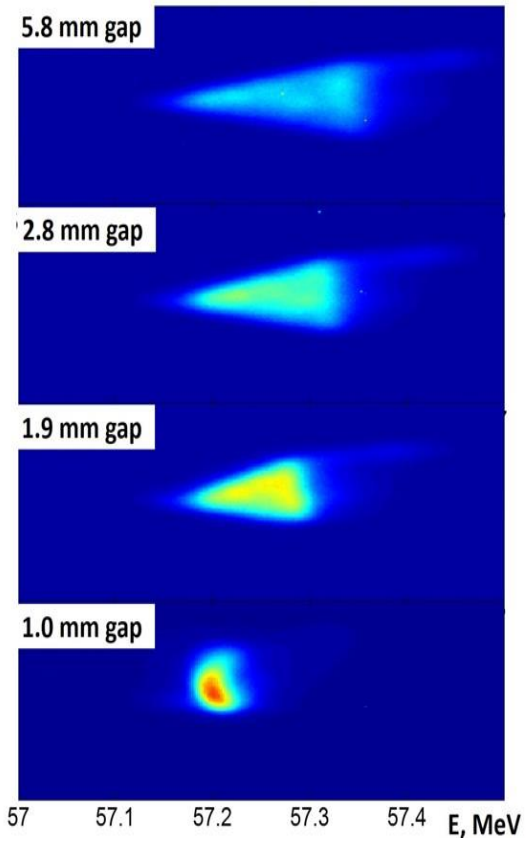


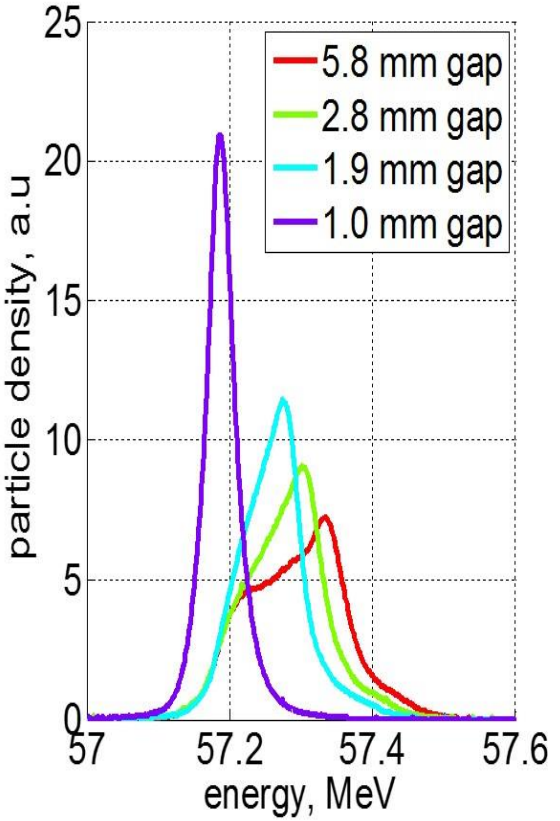
S. Antipov, C. Jing, M. Fedurin, W. Gai, A. Kanareykin, K. Kusche, P. Schoessow, V. Yakimenko, and A. Zholents, Phys. Rev. Lett. 108, 144801 (2012)

Tunable Energy Chirp Correction Experiment at ATF



dechirper: multimode rectangular dielectric loaded waveguide with tunable beam gap



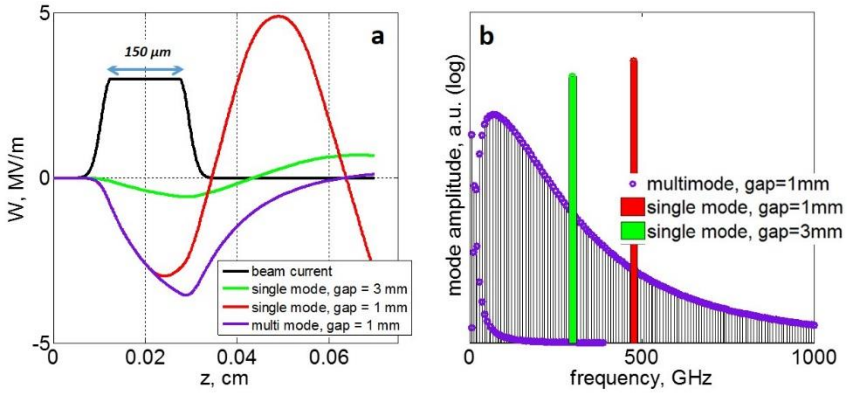


S. Antipov, S. Baturin, C. Jing, M. Fedurin, A. Kanareykin, C. Swinson, P. Schoessow, W. Gai, and A. Zholents, Phys. Rev. Lett. 112, 114801 (2014)

Triangular-shaped (current) beam with energy chirp Correlated energy spread was removed by closing the dechirper gap

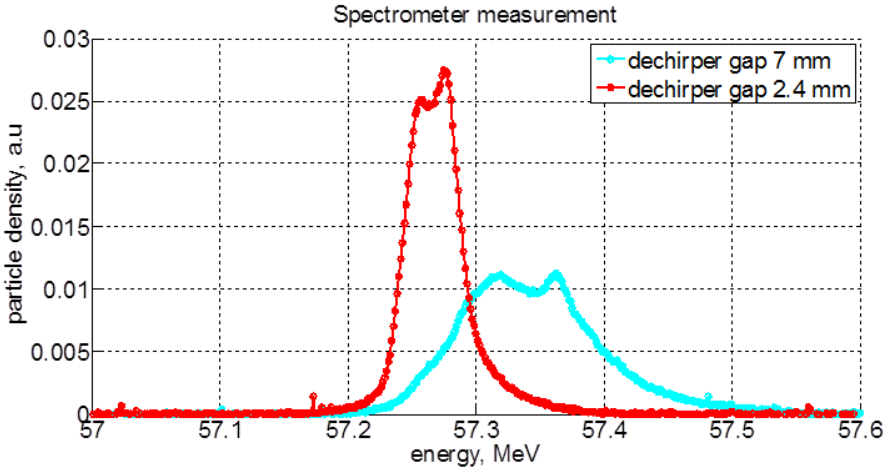
Semiconductor dechirper - collimator!

Dechirpers tested	ATF Ceramic	PAL Copper	ATF Silicon
Q, pC	54	150	90
Structure, L, m	0.1	1	0.1
Gap size, mm	1	5	2.4
ΔE, keV	165	175	90
Strength, MeV/mm/m/nC	61	2.7	33

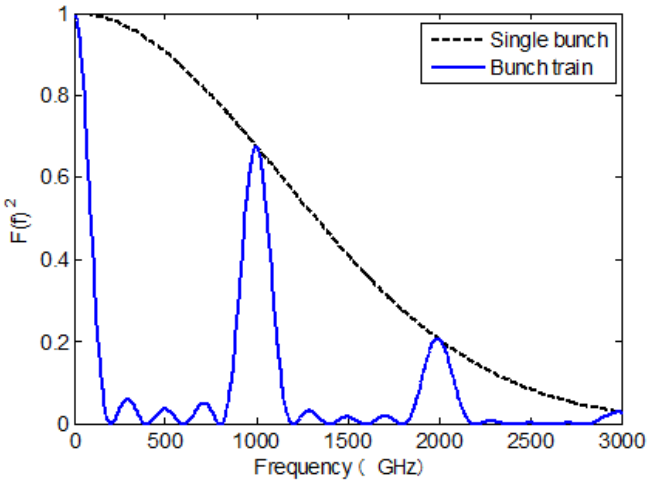


- Semiconductor – resistivity for charge drain
- Balance between σ and ε
- Silicon – doping, radiation hard
- In the experiment: 5kOhm × cm resistivity but skin depth is 35 mm
- **Propose: Dechirper – Collimator!**

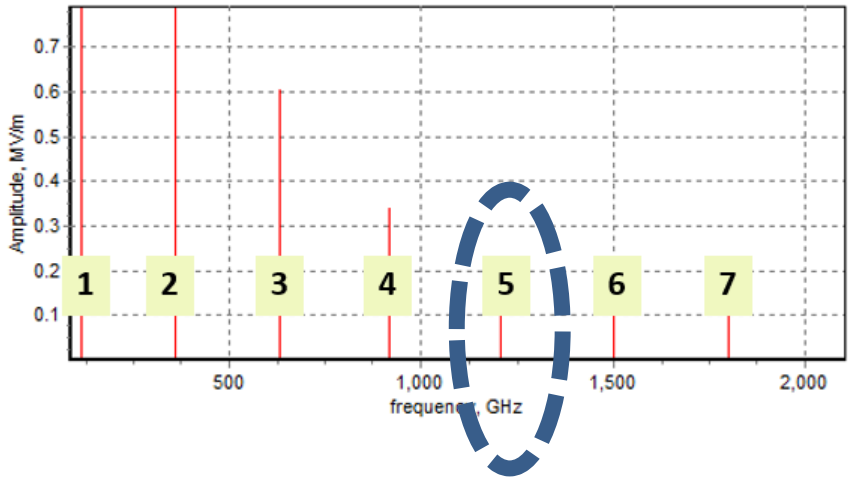
With A. Zholents (APS)



Multimode structure + tunable bunch train



Electron bunch train carries a certain frequency content …

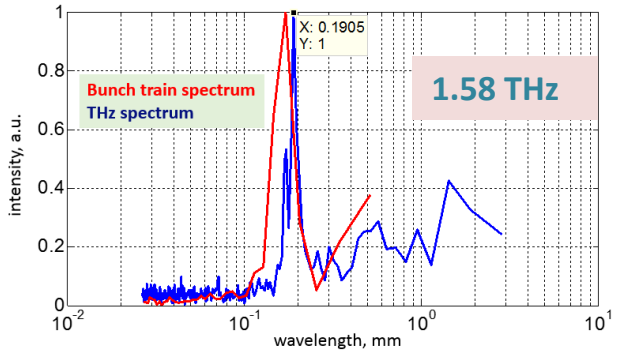


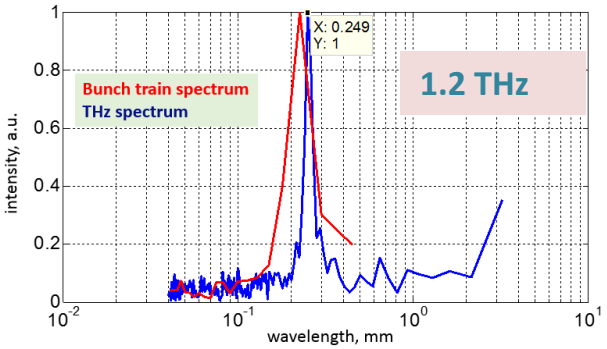
… which can be used to selectively excite high order mode

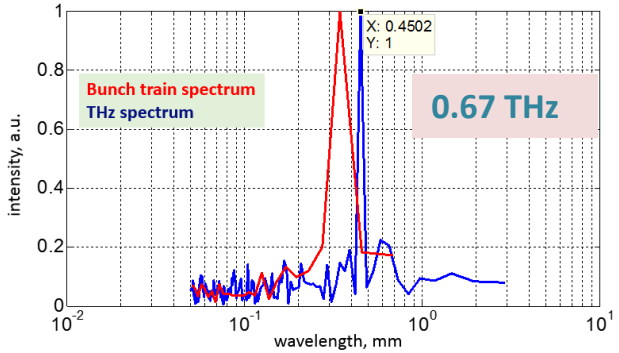
Extending original experiment by ***G. Andonian at ATF Appl. Phys. Lett. 98, 202901 (2011)***

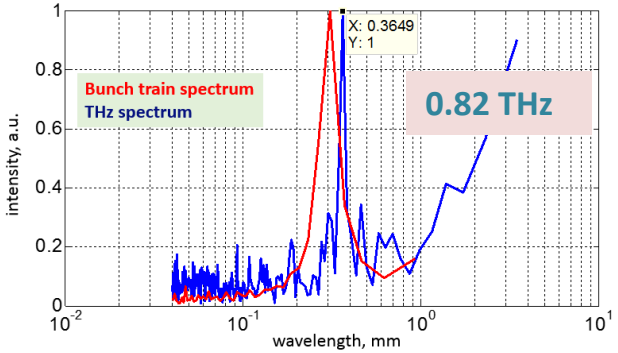
Selective mode excitation (experiment)

In the same structure tunable (by mask) bunch train excites different $TM_{0,n}$ modes







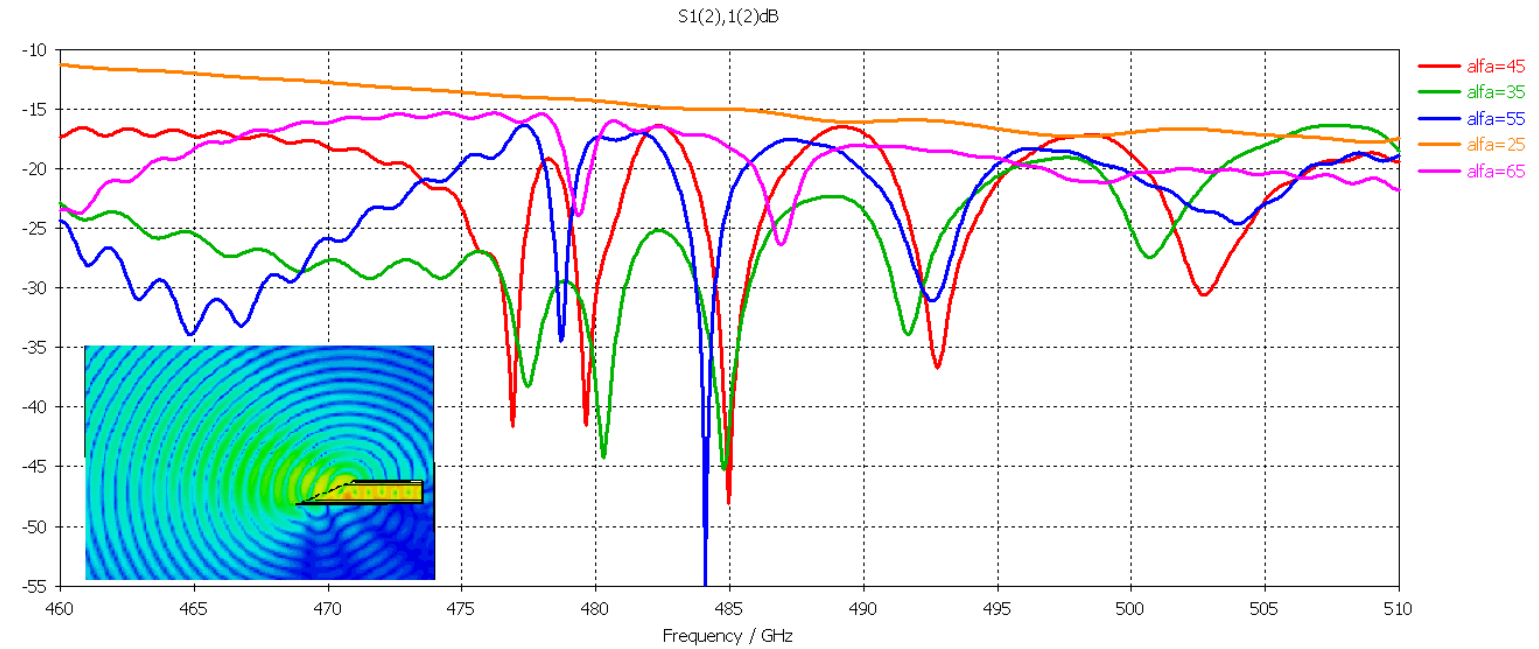


According to theory:
TM_{03}, TM_{04}, TM_{05} and TM_{06}

Experiment at ATF, BNL

S. Antipov, et. al., IPAC (2015)

Efficient power extraction from wakefield structures: “adiabatic” impedance matching with angle cut + directivity

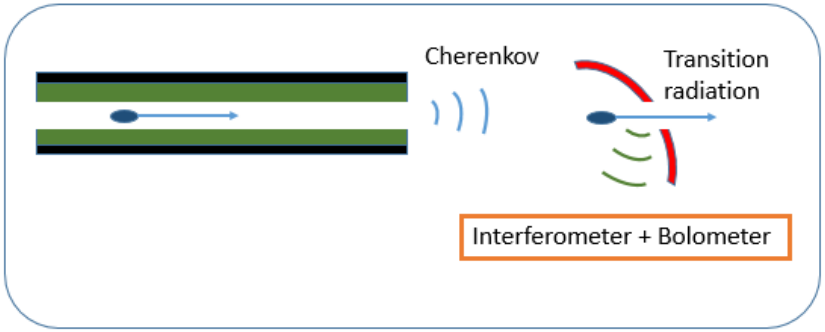


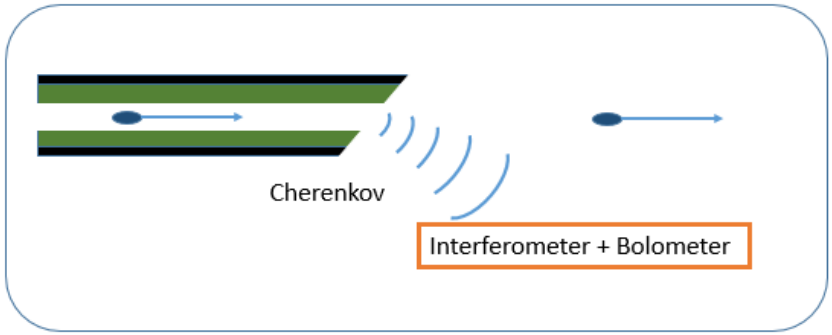
S. Antipov et. al. prepared for publication

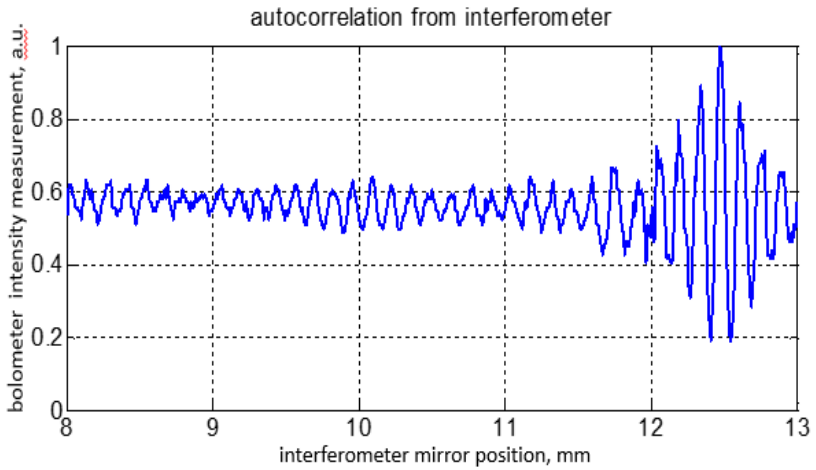
1. >90% power extracted (compared to <10% for straight cut)
2. Emission at an angle to structure axis

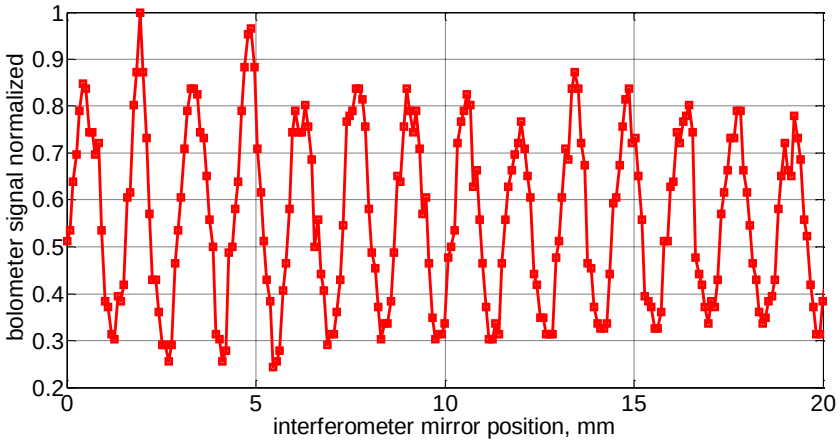
Efficient THz extraction: improved s/n

- Classical configuration
- Recent configuration

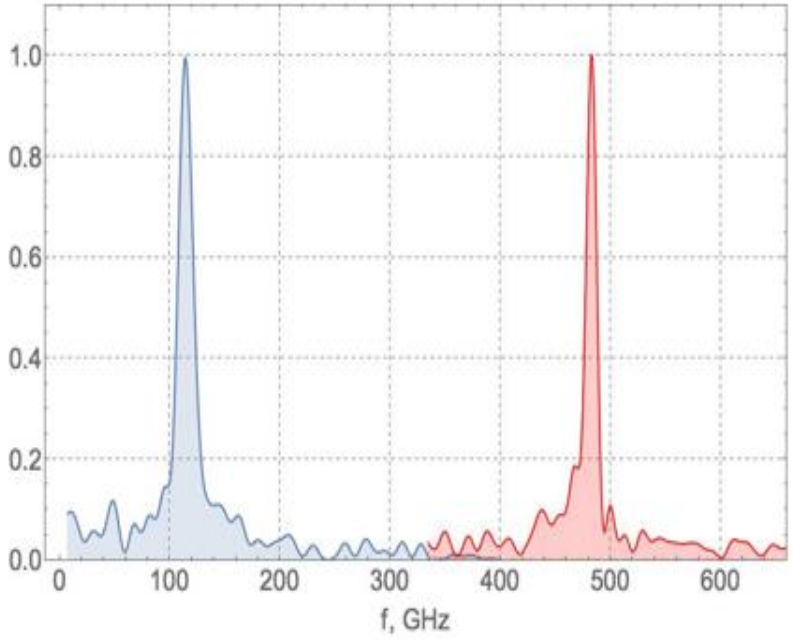


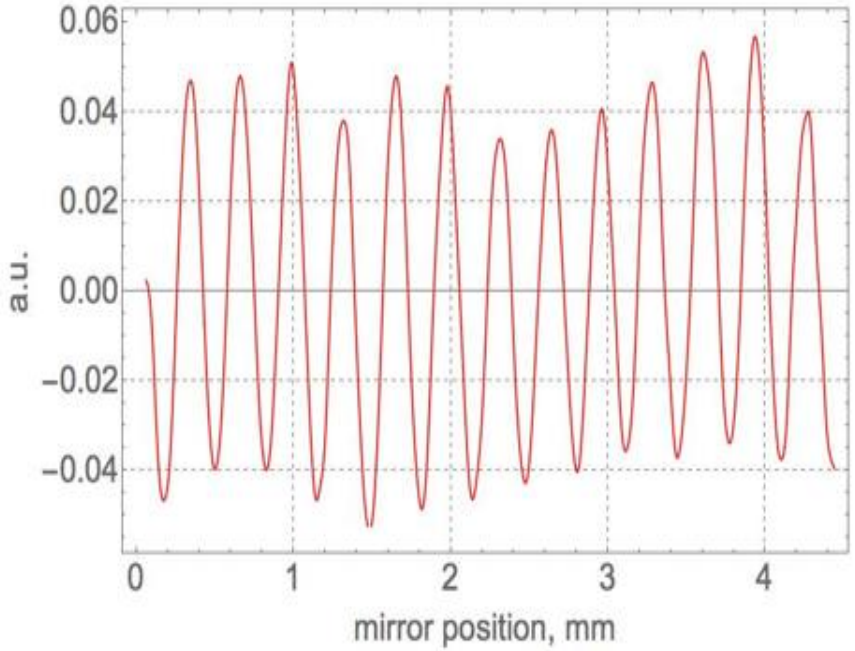




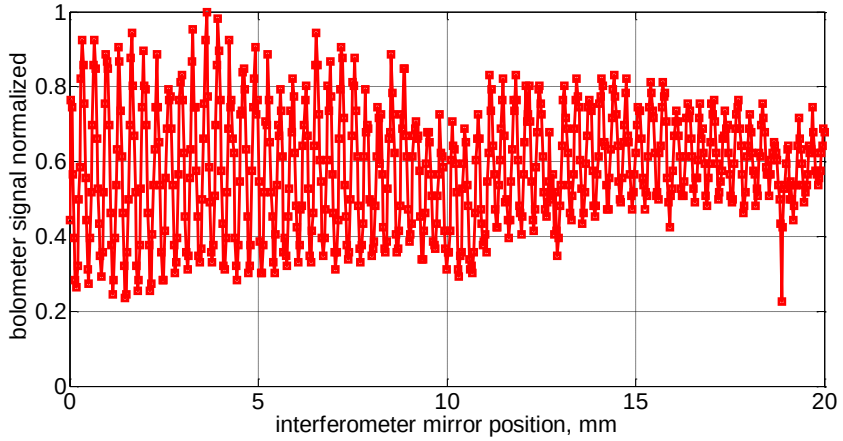


Recent measurements: ~ 100, 500 GHz



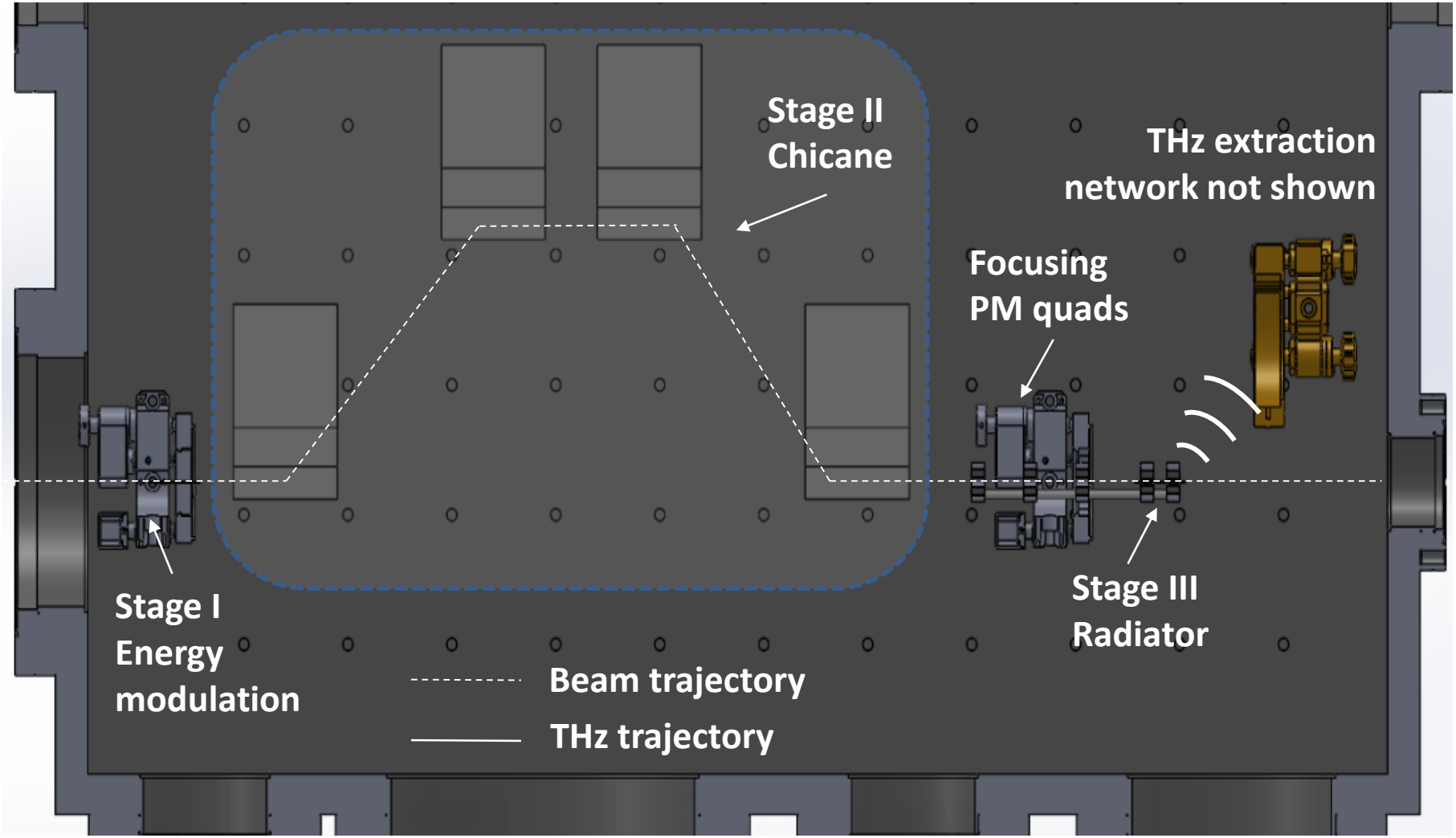


With improved signal / noise we can sample longer signals – narrowband



S. Antipov et. al. prepared for publication

Full – featured experiment – end of 2015



Summary

- 2015 experiments:
  - Semiconductor (tunable) dechirper demonstrated
  - Multimode THz structure selective excitation
  - Efficient THz power extraction
- Plan a 3-stage THz experiment (end of 2015)

Acknowledgements

- Accelerator User Facility Team (BNL)
- Dan Wang, Sasha Zholents (ANL)
- Roman Kostin, Sergey Baryshev, Jiaqi Qiu, Chunguang Jing (Euclid)